DEFINING A PROCESS IN A CREATIVE AND CO-OPERATIVE TECHNOLOGY EDUCATION COURSE

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ABSTRACT

Historically, technology educators have chosen the creation of products or projects as a means to teach technological concepts. Although it is true that technology is most commonly known by its products, in most educational situations technology is best described as a process. This paper describes a technology education course that promotes co-operative and creative problem-solving in primary school teacher education. The purpose of the course was to study creativity through analysing a special method for problem-solving and to create new pedagogical approaches in a learning environment, designed to promote active, co-operative, and problem-centred learning in technology education.

Keywords: Creativity, creative problem solving, technology education

INTRODUCTION

It is very popular to talk about creativity and creative problem solving in common, but it is difficult to define what we really mean by the widespread concept. In this paper creative problem solving is described by analysing a problem solving process, that includes several phases, from recognizing a problem to testing and evaluating it (Fischer 1990, p.39), and in which a small group of students together solve a problem in a technology education context.

It is obvious that creative problem solving forces students to engage in tasks that activate high-order thinking skills, social skills, and problem-solving skills, among others (Kennett & Stedwill 1996). Co-operative groups of two to four members with mixed abilities and roles help students to complete tasks that the individual members may not be able to complete independently. Johnson and Johnson (1991) propose that co-operative learning should be structured taking into consideration the following five elements: 1) the positive interdependence of the group members, 2) individual accountability, 3) face-to-face interaction, 4) social skills development (e.g., communication, trust, leadership, decision making, and conflict management), and 5) assessment of the collaborative efforts of the group.

Creative problem-solving seems to be central to an investigative and active approach to learning, in contrast to “textbook technology” as well as reproductive, teacher dominated work (Sellwood, 1991, pp.4-6). But in spite of several development projects in technology education there still appears to be too much passive learning. Students do routine practical work, but their relationship with the real world is artificial. During their technology classes, students reproduce artefacts according to given models, without any creativity (Weston 1990, p.34). Learning is therefore focused on production skills, with the aim of teaching students how to replicate demonstrated skills (Williams & Williams 1997, p.92).

These kinds of approaches do not prepare students to meet the challenges of modern society and working life, where problem-solving as well as generating alternatives and choosing appropriate ones are significant skills. Maybe that is why many public and private institutions claim that there is a growing need for employees who are able to solve a range of problems (Grabinger 1996, p.665). Several intellectual capabilities and flexible and adaptable skills are required in modern working life. Based on Taousanidis and Antoniadou´s (2003, p.68) ideas capabilities needed in working life can be grouped as:

Problem solving capabilities:	Co-operative capabilities:
1. Ability to plan and organize	1. Ability to work with others (teamwork)
2. Ability to collect and analyse data	2. Ability to communicate effectively
3. Ability to solve problems	3. Willingness to take on responsibilities
4. Critical thinking	4. Self management
	5. Learning how to learn

These generic skills apply to all sectors of working life. The specific skills, which are related to specific jobs are quickly becoming obsolete, and they will have to be updated through the process of lifelong learning.

Creative and Co-operative Problem Solving

Numerous models for curriculum changes in technology education, as well as for introducing creative problem-solving processes, are available nowadays, both in technology education literature and school textbooks (Johnsey, 1995). Nevertheless, there still appears to be an overemphasis on passive learning and the old traditions of craft learning (Kimbell, 1997, p.229). Moreover, some renewed curriculum models easily lead to a situation in which the construction phase immediately follows the planning phase, without enough time for conceptualisation, ideation, and the evaluation of ideas (e.g. Elmer & Davies, 2000; Alamäki, 2000). An especially important aspect of technology education and teacher education is providing the opportunity to get away from routine activities and low-level thinking, so that students can find fresh new ideas and approaches, for example, by utilizing group dynamics or special creative methods (e.g., Smith, 1998, pp.107133).

Different ways to emphasize creative problem solving in small groups have been suggested (e.g., Grabinger, 1996, p.665; Dooley, 1997; Hill, 1999). A common feature of these approaches is to place students in the midst of a realistic, ill-defined, complex, and meaningful problem, with no obvious or correct solution. Students work in teams, collaborate and act as professionals, confronting problems as they occur – with no absolute boundaries. Although they get insufficient information, the students must settle on the best possible solution by a given date. This type of multi-staged process is characteristic of effective and creative problem solving. According to Fischer (1990, p.39) these stages may include: 1. Formulating the problem, 2. Recognition of facts related to the problem, 3. Goal setting ideation or generating alternatives , 4. The evaluation of ideas, 5. Choosing the solution and 6. Testing and evaluating.

When problem-solving is creative, the ideas or products produced during the problem-solving process are both original and appropriate (Fisher, 1990, pp.2931). For these purposes, various idea-generation techniques or ideation models are valuable (Smith, 1998). The number of alternative solutions is important, because the best way to come up with good ideas is to have plenty of choice (Parker, 1991).

Consequently, the outcome of creative problem-solving activities depends largely on the creative processes and ideation techniques that have been learned and applied. Furthermore, there are factors of attitude (interest, motivation, and confidence), cognitive ability (knowledge, memory, and thinking-skill), and experience (familiarity with content, context, and strategies) that influence problem-solving processes (Fisher, 1990, p.112). For example, non-judgmental positive feedback and the acceptance of all ideas, even absurd or impractical ones, are important in all creative group processes for generating significant alternatives (Higgins, 1994, p.119). There should be room for free ideation sessions. Evaluative critiques should only take place afterwards.

According to Strzalecki (2000, pp.242-247) we can identify certain factors related to the personal abilities and different styles of problem solving in the problem solving process. These elements can be presented in the following figure.

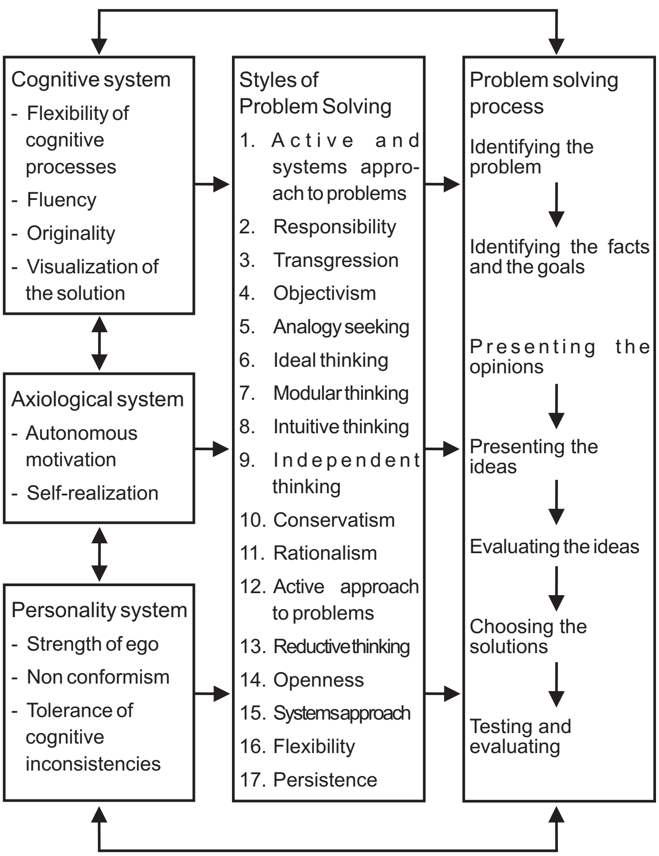


Figure 1. *Simplified model of the elements in creative problem solving process. Co-operation of the personal factors and styles of solving problems.*

The creative and co-operative technology education course

The plan of the creative and co-operative technology education course was based on the assumption that co-operative and creative problem solving would be valuable for developing a premium technology education study module for primary school teacher education. The purpose of the study was to discover students´ creativity by perceiving the creative process, and to find out to what extent they learn creative skills, especially those that involve generating alternative ideas and the self-evaluation of these alternatives.

Another goal of the course was to introduce our student teachers to methods they can use to help pupils to work co-operatively when they solve problems and make decisions during a technology education course in their own schools.

In practice, our student teachers were to compose, plan and create autonomously something new, an innovative technological product. It could be a functioning apparatus or a toy, a system or a process related to such themes as levers, crankshafts, gearwheels or moving and flying objects.

To help our students to become familiar with problem solving and decision-making processes, ideation techniques, and the evaluation of ideas, we included in the ideation process a practical problem-solving model and the Overall Mapping of a Problem Situation (OMPS) method.

At the beginning of the course, the students attended two hours of lectures and demonstrations about creative problem-solving. The sessions covered different idea generation techniques, such as brainstorming and analogous thinking. In addition, the students became

familiar with the theme through WWW pages (Lavonen & Meisalo, 2001) that presented problem-solving models and several idea-generating techniques, such as the OMPS (cf., Sellwood, 1991, p.5). Different (e.g., creative, social and personal) abilities and skills needed in creative problem solving, as well as ways to establish a creative and open atmosphere, were discussed. After the above-mentioned sessions, a four-hour workshop was organized in which the students worked in small groups. In these workshops, students became familiar with the OMPS method by using it to plan a bridge or tower to be constructed out of newspapers.

During the planning phase of the project (four to eight hours), the groups of 3-4 students worked in 24 collaborative teams according to the basic principles of the OMPS method, and generated a map of the creative process (Figure 2).

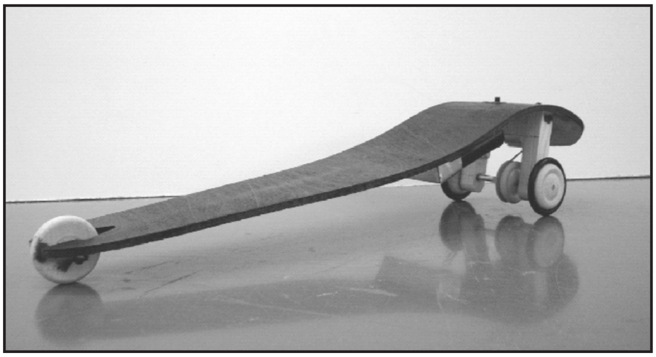
The Problem: How to design a moving vehicle			
Facts: - Time limit - Electricity - Mechanics - Toy	**Opinions:** - Beautiful - Simple enough - Do we have enough skills? - Recycling materials	**Goals:** - Useful - Moving vehicle - Modern - Must finish in time	**Visions:** -Artistic -Best seller -Creative
Approach A: Flying **Idea A1:** Airplane + Traditional + Interesting + Many options ? Does it fly? **Idea A2:** Helicopter + Not so usual + Innovative + Interesting + Exciting ? Is it flying **Idea A3:** Air balloon + Can really fly + Learn physics	**Approach B:** A car **Idea B1:** Police car + Easy to make + Kids like it + Interesting ? How to put something unusual **Idea B2:** Ambulance + Lights fit well with the idea + Interesting + Exciting ? How to get lights blinking **Idea B3:** Fire truck + Exciting	**Approach C:** A Ship **Idea C1:** Titanic + Easy + Traditional + Motivating story ? How to put something unusual **Idea C2:** Wing wheel + Innovative + Mechanics fit well + Interesting ? How to manage in time **Idea C3:** Submarine + Exciting + Periscope ? Does it really work?	**Approach D:** Stories **Idea D1:** Time machine + Historical perspective + Exciting + Innovative ? How to manage in time **Idea D2:** UFO + Innovative + Lights fit well + Futuristic perspective ? Mechanics **Idea D3:** Cows flying + Innovative + Not traditional ? How to keep in the air

Figure 2: An example of a planning process expressed by a map constructed during the creative phase. In this phase, the primary school student teachers utilized the method of Overall Mapping of a Problem Situation, OMPS.

In the process: 1. the students had to first find, formulate and specify the problem, and recognize the facts (agreed by the team) and opinions related to the problem. 2. Next, the teams set the problem or team assignments in a cogent phrase, such as: How can an interesting electric toy be constructed? 3. In addition, the students had to set the goals and visions (ideal performance). 4. Then, the students had to create suitable approaches for solving the problem, and to generate problem-solving alternatives. 5. Every alternative idea was subsequently backed-up by presenting at least three reasons for its adoption. Non-judgmental positive feedback and the acceptance of all ideas, even absurd or impractical ones, were held as important rules during all group processes that generated creative alternatives (Higgins, 1994, p.119).

After generating dozens of ideas, students chose the most appropriate solution by comparing the positive feedback and constructive questions that related to each idea. Typically, the final solution was a combination of several original ideas. During the ideation phase, the students were encouraged to follow the creative rules, and to utilize idea generation techniques while working in co-operative groups. After selecting the final ideas, students then planned how they would construct the structure or perform the process.

After generating alternatives, evaluating them, and designing and planning the project, the students created something new in their design solution process, utilizing paperboard, wood, metal, and/or plastic, and the appropriate tools. The teams spent approximately 12 hours in the workshop, and worked according to their previously agreed plans. The intention was that the students would be creative in their teams, and would modify their preliminary plans during the practical work period. Finally, each team presented their innovations to the other groups, and evaluated both the innovations and the entire process, first by themselves and then with the others. The construction and evaluating phases are not included in this paper.



Implementation of the Study

Of the 118 participating students, 80% were female, and were on average 24 years old. According to the collected background information, 77% of the students had little or no previous knowledge or experience regarding the contents and methods of technology education. Less than 10% of them, however, disagreed with statements indicating high motivation and responsibility in their work, as well as success in planning and collaboration during the course. Only about 15% of the participating students thought that the course was of little significance to the primary school teaching profession, or that the course offers little that is applicable to their profession. It can be concluded, therefore, that the students' attitudes to the project were largely positive and that they agreed with the project goals.

To evaluate the creative problem-solving processes, a questionnaire consisting of 23 items was utilized, thereby yielding self-evaluative data concerning the students' success as regards the conceptualisation and evaluation of ideas, as well as on their success with creative problem-solving. Of the 118 students who participated in the project, 85 students answered the questionnaire. More specific results extracted from the questionnaire can be found in an article published earlier (Lavonen, Autio & Meisalo, 2004).

Furthermore, three different groups of three to four members were selected to be video taped. The videotapes were later analysed focusing on the steps in the creative problem-solving process and styles of problem solving process (figure 1). This paper concentrates on these results.

Empirical study

Although all our students had to fill in a questionnaire consisting of 23 items, the video recordings were used, in this paper, as a main data collecting method. The recordings were carried out in the middle of the project, when students worked in groups of three to four persons. The recordings were made beginning from the idea generating process and continuing until the students had chosen the alternative to generate further in the practical workshop. Each recording approximately lasted for one hour. Consequently, we recorded a total of 3 hours and 18 minutes of the students´ activities. The videos include all kinds of student activities related to the idea generating process, and the students´ discussions can be clearly heard on the tapes.

After the recordings, the researcher viewed the videotapes twice and discussed the preliminary findings with colleagues. After that, he transliterated all verbal and non-verbal events on the videos. He played and replayed the videos at least four times to find out the specific meaning of all episodes, and transcribed all natural talk between the students. These notes comprised about 40 standard pages.

In analysing the data, the categories used were derived from our theoretical background, as well as concluded by induction from the video notes. The main and subcategories, their definitions, and typical examples taken directly from the categories are presented in Table 1.

Code	Description of the category	Example
+	positive verbal or nonverbal feedback	That is ok.
++	very positive feedback	*That is very good.*
o	neutral feedback	*I do not know about that.*
-	negative feedback	*I do not like that idea.*
1	Identifying the problem	*What is our problem in this project?*
1.2.	facts related to the problem	*It must be a toy.*
1.4.	ideation of the problem	*A toy with some mechanics and electricity.*
1.5.	evaluation of the problem	*Is it just a toy or something else?*
2	Identifying the facts and the goals	*We must finish this in 10 hours.*
2.3.	opinions related to the goals	*It must be nice and sweet.*
2.4.	ideation of the goals	*Is one of our goals that we really learn something*
2.5.	evaluation of the goals	*Is aesthetics really so important?*
3	Presenting the opinions	*These are just our own opinions not facts*
3.5.	evaluation of the opinions	*Do we really have to use the toy*
3.8.	development of the opinions	*We must built something that is useful*
4	Presenting the idea	*Can we build a car?*
4.2.	facts related to the idea	*There must be lights on it.*
4.3.	opinions related to the idea	*Yes, but it must be simple enough.*
4.5.	evaluation of the idea	*It is easy to put electricity and mechanics on it.*
4.8.	development of the idea	*We can build a racing car.*
5	Evaluation	*Is this really a good idea?*
5.3.	opinions related to the evaluation	*First we must have plenty of ideas.*
6	Choosing the alternatives	*I like the idea of a racing car.*
6.3.	opinions related to the alternatives	*It is a good idea if we can make it simple enough.*
6.5.	evaluation related to the alternatives	*There are many positive things on this idea.*
7	Experimentation	Not included

Table 1: Descriptions of the categories of tasks in problem-solving activities and examples of students´ typical behaviour in different categories.

After defining the categories (Table 1.), all videotaped activities were analysed. Altogether there were 570 spoken episodes during one 60 minute videotaped period, with an average of 6,3 seconds duration. Besides that, 242 episodes of verbal or non-verbal feedback were registered.

In the next phase the 60 minutes video recording was split into three 20 minutes periods to find out what kind of social interaction is typical to each stage of creative problem solving and decision making process. The frequencies of each category defined in the previous chapter are presented in table 2.

Most of the feedback given to other students was positive (160 episodes / 67%). Neutral feedback was given in 76 episodes (31%) and negative feedback only in 6 episodes (2%). So the idea of non-judgmental positive feedback and the acceptance of all ideas, even absurd or impractical ones was fullfilled and there seemed to be room for free ideation.

In the whole 60 minutes process the most typical of students´ problem solving activities were development of the ideas 191 episodes (36% of all episodes), evaluation of the ideas 137 episodes (24%) and presenting the ideas 98 episodes (17%).

In 20 minutes periods most of the facts and the goals were discussed in first 20 minutes. Also the problem was identified and most of the opinions were presented in first 20 minutes period.

The real idea generating process started already in first 20 minutes, but it accelerated all the time during the whole 60 minutes period. Most of the ideas (58 episodes /59%) were presented in second 20 minutes period, 14 episodes (14%) occurred in first period and 26 episodes (27%) in last 20 minutes period.

Only 26 episodes (13%) in development of the ideas occurred in first 20 minutes, but already 70 episodes (37%) in the second and as much as 95 episodes (50%) in the last 20 minutes period. It seems that if we want to get plenty of ideas the idea generating process must last at least 30 minutes. If the idea generating process is shorter the ideas usually are quite traditional and do not fullfill the idea of real innovative process.

Styles of Solving Problems (amount of episodes)	Identifying the problem Frequencies	Identifying the facts Frequencies	Presenting the opinions Frequencies	Presenting the idea Frequencies	Evaluation the idea Frequencies	Choosing the alternatives Frequencies
1. Active and systems approach to problems (26)	3	6	5	10	2	
2. Responsibility (42)	2	5	2	6	27	
3. Transgression (12)	2		3	5	2	
4. Objectivism (44)	1	3		15	25	
5. Analogy seeking (19)				19		
6. Modular thinking (21)		3	2	7	9	
7. Intuitive thinking (83)			4	75	4	
8. Conservatism (41)	6	8	12	9	6	
9. Rationalism (73)	7	5	10	36	14	1
10. Reductive thinking (42)				6	34	2
11. Openness (63)			5	52	5	1
12. Flexibility (104)		1	6	85	12	
Total (570)	21	31	49	325	140	4

Table 2: The frequencies of each category based on the description presented in table 1.

Discussion

This project allows us to conclude that creativity cannot be taught directly, but it could be learned effectively through a co-operative creative problem solving process. At least the students felt and the data confirms (see Table 2), that they had learned to give positive feedback regarding other students' ideas, and to recognize the advantages of those ideas, and even to develop them further. Present findings also suggest that the students worked co-operatively. The students shared their cognitive resources, talked, recognized facts, planned, and evaluated with the aim of solving problems and producing a single outcome through dialogue and action.

It is obvious that a formal method, in which each idea must be backed up by the presentation of at least three reasons for its adoption, is necessary for success in the beginning. Such evaluation creates a non-judgmental positive atmosphere for creativity, and it helps to behave positively. Also, it could be effectively argued that the Overall Mapping of a Problem Situation (OMPS) method helps students understand the nature of creative processes, and particularly that there are different phases involved in each of these processes.

Moreover, it seems that co-operative and creative learning approaches are also suitable for school classrooms. Therefore it is obvious that students should be introduced to creative problem solving in general, and to practical problem-solving in particular, among the other pedagogical approaches. In summary, this project indicates that creative problem-solving approaches may be efficiently used to improve teacher training.

From the point of view of similar future projects, it is important to observe that students´ should receive more introductions to creative problem solving in general. In addition more efficient guidance in generating alternatives is also needed before the project. Although the students attended two hours of lectures and demonstrations about creative problem-solving, and they became familiar with the theme through WWW pages, learning was not too active when the lectures were given using traditional methods. As the students were directly taught very little, they did not have enough planning and ideation skills. Actually, though manuals and handbooks were available all the time, the difficulty was that students did not have much time to learn new knowledge during the active process.

Although uncertainty and tolerance of cognitive inconsistencies are some of the main elements in creative work (Strzalecki 2000, p.244), better guidance in creative problem-solving methods should be taken into consideration, because many students became anxious when no formula existed, or no direct guidance was given about in how they should work.

It is easy to talk about creative problem solving in general, but organizing co-operative problem-solving situations and learning activities is not as easy as it seems, and it is even more difficult to measure this process with reliable methods. It will be interesting to see how our findings can be put into practice. We are continuing our efforts in several related projects.

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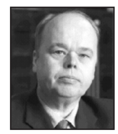

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